

Claims

What is claimed is:

1. A computer-implemented method for generating graphical warps or deformations through transformation of an undeformed model to a deformed model, said computer-implemented method comprising:
 - 4 receiving said undeformed model and a set of feature specifications each of said set of feature specifications comprising a source feature, a target feature, and related deformation parameters;
 - 7 receiving a set of transformations corresponding to said set of feature specifications and for mapping said source feature to said target feature in each of said set of feature specifications;
 - 10 receiving a set of strength fields corresponding to said set of feature specifications and defined over said undeformed model for scaling the magnitude of each of said set of transformations, establishing a set of scaled transformations;
 - 13 receiving a set of weighting fields corresponding to said set of feature specifications and defined over said undeformed model for determining the relative influence of said set of scaled transformations;
 - 16 computing a sum of said set of scaled transformations weighted by said set of weighting fields, for deforming said undeformed model to generate said deformed model; and
 - 19 returning said deformed model.
1. 2. The computer-implemented method according to claim 1 wherein at least one of said set of feature specifications is continuous and has corresponding parameterized strength field, transformation, and weighting field, and further comprising:
 - 4 receiving a sampling function for discretizing said parameterized transformation and sampling said strength field and said weighting field;
 - 5 computing a discretized transformation, a sampled strength field, and a sampled

7 weighting field with said sampling function; and wherein said step of computing an
8 sum of said set of scaled transformations employs said discretized transformation,
9 said sampled strength field, and said sampled weighting field.

1 3. The computer-implemented method according to claim 2 wherein said set of feature
2 specifications, said set of transformations, said set of strength fields, said set of
3 weighting fields, and said sampling function are received by a combined function
4 that computes said discretized transformation, said sampled strength field, and said
5 sampled weighting field.

1 4. The computer-implemented method according to claim 1 wherein:
2 said set of feature specifications comprises a plurality of line segment features;
3 said set of transformations corresponding to said plurality of line segment features
4 map source coordinate frames to target coordinate frames; and
5 said set of weighting fields corresponding said plurality of line segment features fall
6 off with distance.

1 5. The computer-implemented method according to claim 4 wherein:
2 said set of weighting fields give influence to line segment features in said plurality of
3 line segment features in relation to their length.

1 6. The computer-implemented method according to claim 4 wherein:
2 said source coordinate frames comprise a constrained basis vector and an
3 unconstrained basis vector and wherein said unconstrained basis vector is selected
4 responsive to a weighted sum of the vectors perpendicular to the constrained basis
5 vector for each of said target coordinate frames.

1 7. The computer-implemented method according to claim 1 wherein:
2 said set of feature specifications comprises control points in an at least two

- 3 dimensional lattice; said at least two dimensional lattice having an associated local
4 coordinate system;
- 5 said set of weighting fields corresponding to said control points comprise Bernstein
6 polynomials with arguments comprising points of said undeformed model
7 represented in said local coordinate system.
- 1 8. The computer-implemented method according to claim 1 wherein:
2 said set of feature specifications comprises an oriented point in an at least two
3 dimensional lattice; said at least two dimensional lattice having an associated local
4 coordinate system;
5 the transformation in said set of transformations corresponding to said oriented
6 maps a source coordinate frame to a target coordinate frames; and
7 said set of weighting fields corresponding to said oriented points comprise
8 Bernstein polynomials with arguments comprising points of said undeformed
9 model represented in said local coordinate system.
- 1 9. The computer-implemented method according to claim 1 wherein:
2 said set of transformations comprises a geometrically parameterized transformation.
- 1 10. The computer-implemented method according to claim 9 wherein:
2 said set of transformations comprises plural geometrically parameterized
3 transformations; and
4 said set of strength fields modulate said plural geometrically parameterized
5 transformations.
- 1 11. The computer-implemented method according to claim 10 wherein:
2 said set of weighting fields blend said plural geometrically parameterized
3 transformations.

- 1 12. The computer-implemented method according to claim 1 wherein:
- 2 at least one of said set of feature specifications comprises a source curve and a
- 3 target curve;
- 4 corresponding members of said set of transformations comprise a composition of a
- 5 translation from points along said source curve to points along said target curve, a
- 6 rotation taking the tangent at said points along said source curve to the tangent at
- 7 said points along said target curve, and a scale centered at said points along said
- 8 source curve;
- 9 corresponding members of said set of strength fields comprise a falloff function
- 10 having a domain and a range and monotonically decreasing over said range, and
- 11 wherein over at least a portion of said domain arguments of said falloff function
- 12 comprise a distance between points of said undeformed model and point along said
- 13 source curve and a rate of falloff for said distance.
- 14 corresponding members of said set of weighting fields comprise a scaled
- 15 displacement function having a domain and a range, wherein for at least a portion
- 16 of said domain said scaled displacement function comprises a power of the
- 17 displacement of elements of said undeformed model by said corresponding
- 18 members of said set of transformations.
- 1 13. The computer-implemented method according to claim 12 wherein said scaled
- 2 displacement function comprises a power of the displacement of elements of said
- 3 undeformed model by said corresponding members of said set of transformations
- 4 for the entirety of said domain.
- 1 14. The computer-implemented method according to claim 1 wherein:
- 2 said undeformed model comprises control vertices of a fine surface model; and
- 3 at least one of said set of feature specifications comprise:

4 a source position and a target position of one or more vertices of a coarse
5 deformation mesh configured for deformation of said fine surface model, and
6 a set of edges incident on said one or more vertices.

1 15. The computer-implemented method according to claim 14 wherein:

2 corresponding members of said set of transformations comprise a composition of:

3 a translation mapping said source position to said target position, and
4 at least an approximation of a mapping of said set of edges in said undeformed
5 model to said deformed model.

1 16. The computer-implemented method according to claim 15 wherein:

2 corresponding members of said set of weighting fields comprise a falloff function, said
3 falloff function substantially zero at a distal end of each of said set edges incident on
4 said one or more vertices, and said falloff function substantially at its maximum value
5 for arguments proximate to said source positions of said control vertices.

1 17. The computer-implemented method according to claim 1 wherein:

2 said undeformed model comprises control vertices of a surface for deformation,
3 wherein source and target features are parameterized as a function that returns a
4 tuple comprising a point and a vector normal to said point;

5 at least one of said set of feature specifications comprises a source region and a
6 target region;

7 corresponding members of said set of transformations comprise a composition of:

8 a translation mapping points on said source region to points on said target region,
9 and

- 10 a rotation taking said vector normal to said points on said source region to said
11 vector normal to said points on said target region of said surface.
- 1 18. The computer-implemented method according to claim 17 wherein corresponding
2 members of said set of strength fields localize the effect of said set of
3 transformations around said source surface region.
- 1 19. The computer-implemented method according to claim 18 wherein:
2 corresponding members of said set of weighting fields decrease monotonically with
3 corresponding members of said set of strength fields and wherein said set of weighting
4 fields decrease responsive to:
5 a distance between control vertices of said surface for deformation and said point
6 on said surface, and
7 a range for limiting the region of said weighting field, and
8 a rate for controlling the rate of decrease of said weighting field.
- 1 20. The computer-implemented method according to claim 1 wherein:
2 one of said set of feature specifications act with substantially full strength across said
3 undeformed model and corresponding the member of said set of weighting fields
4 dominates weighting contributions of other members of said set of weighting fields.